

ajc



PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re U.S. Patent No. 7,069,208 ) Serial No. 09/770,113  
)  
Inventor(s): Ye WANG ) Filed: January 24, 2001  
)  
Issue Date: June 27, 2006 ) Attorney Docket No. 004770.00012

For: SYSTEM AND METHOD FOR CONCEALMENT OF DATA LOSS IN DIGITAL AUDIO TRANSMISSION

**REQUEST FOR CERTIFICATE OF CORRECTION**

U.S. Patent and Trademark Office  
Customer Service Window  
Randolph Building, Mail Stop: Certificate of Correction Branch  
401 Dulany Street  
Alexandria, VA 22314

Sir:

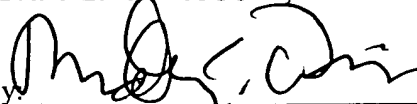
Pursuant to 35 U.S.C. § 254 and 37 C.F.R. § 1.322, this is a request for the issuance of a Certificate of Correction in the above-identified patent. Two (2) copies of PTO Form 1050 are appended. The complete Certificate of Correction involves one page.

The mistakes identified in the appended Form occurred through no fault of the Applicant, as clearly disclosed by the records of the application, which matured into this patent. Enclosed for your convenience are initialed copies of the pertinent USPTO 1449 forms, and the first two pages of the Office communications which they accompanied.

We respectfully request issuance of the Certificate of Correction containing the aforementioned corrections. Since these changes are necessitated through no fault of the Applicant, no fee is believed to be associated with this request. Nonetheless, should the Patent and Trademark Office determine that a fee is required, please charge our Deposit Account No. 19-0733.

Respectfully submitted,

BANNER & WITCOFF, LTD.

By: 

Bradley C. Wright  
Registration No. 38,061

**Certificate**

DEC 01 2006

**of Correction**

Dated: November 27, 2006

1001 G Street, N.W. (11th Fl.)  
Washington, D.C. 20001  
(202) 824-3000

DEC 04 2006

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO.: 7,069,208  
DATED: June 27, 2006  
INVENTOR(S): Ye WANG

It is certified that errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the second page of the cover page, under Other Publications, 11<sup>th</sup> reference:  
“<http://ccma-www.stanford.edu/bosse/proj/node27.html>” has been replaced with  
--<http://ccrma-www.stanford.edu/~bosse/proj/node27.html>—

On the second page of the cover page, under Other Publications, 12<sup>th</sup> reference:  
“<http://www.lis.fhg.de/amm/techint/layer3/index.html>” has been replaced with  
--<http://www.iis.fhg.de/amm/techinf/layer3/index.html>—

On the second page of the cover page, under Other Publications, 29<sup>th</sup> reference:  
“Lapped Transform” has been replaced with --Lapped Transforms for Transform--

Mailing Address of Sender:

Banner & Witcoff, Ltd.  
11th Floor  
1001 G Street, N.W.  
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U.S. PAT. NO 7,069,208

No. of add'l copies  
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□

FORM PTO 1050 (Rev.2-93)

DEC 04 2006

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

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DATED: June 27, 2006  
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2006 JUN 27



# UNITED STATES PATENT AND TRADEMARK OFFICE

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United States Patent and Trademark Office  
Address: COMMISSIONER FOR PATENTS  
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Alexandria, Virginia 22313-1450  
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,113	01/24/2001	Ye Wang	04770-00012	5357

7590 04/07/2006  
Joseph Stecewycz  
BANNER & WITCOFF, LTD.  
28 State Street, 28th Floor  
Boston, MA 02109



EXAMINER

JACKSON, JAKIEDA R

ART UNIT	PAPER NUMBER
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2626

DATE MAILED: 04/07/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

**Supplemental  
Notice of Allowability**

Application No.

09/770,113

Examiner

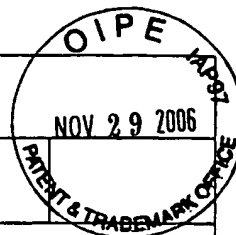
Jakieda R. Jackson

Applicant(s)

WANG, YE

Art Unit

2626



-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to August 26, 2005.
2. ☒ The allowed claim(s) is/are 1-8,10,12,16 and 19-49.
3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some\* c) ☐ None of the:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

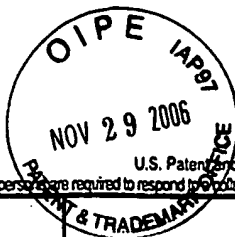
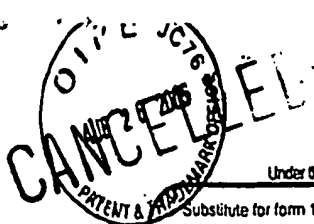
\* Certified copies not received: \_\_\_\_\_.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.  
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.**

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
- (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
- 1) ☐ hereto or 2) ☐ to Paper No./Mail Date \_\_\_\_\_.
- (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date \_\_\_\_\_.
- Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO-1449 or PTO/SB/08),  
Paper No./Mail Date \_\_\_\_\_
4. ☐ Examiner's Comment Regarding Requirement for Deposit  
of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413),  
Paper No./Mail Date \_\_\_\_\_
7. ☒ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other \_\_\_\_\_



113PTO/SB/08a (08-03)

Approved for use through 07/31/2006. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no person is required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449A/PTO

**INFORMATION DISCLOSURE  
STATEMENT BY APPLICANT**

(Use as many sheets as necessary)

Sheet 1 of 1

Complete if Known

Application Number	09/770,113
Filing Date	January 24, 2001
First Named Inventor	Ye WANG
Art Unit	2655
Examiner Name	Jakieda R. Jackson
Attorney Docket Number	004770.00012

**U.S. PATENT DOCUMENTS**

Examiner Initials *	Cite No. <sup>1</sup>	Document Number	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		Number - Kind Code <sup>2</sup> (if known)			
		US - 5,394,473 A	02-1995	Davidson	
		US - 6,005,658	12-1999	Kaluza, et al.	
		US - 6,115,689 A	09-2000	Malvar	
		US - 6,477,150	11-2002	Maggenli, et al.	
		US - 6,597,861	07-2003	Cooke	
		US - 6,787,689	09-2004	Chen, Fang-Chu	
		US - 6,807,526	10-2004	Touimi, et al.	

**NON PATENT LITERATURE DOCUMENTS**

Examiner Initials *	Cite No. <sup>1</sup>	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T <sup>2</sup>
		Malvar, "Biorthogonal and Nonuniform Lapped Transforms for Transform Coding with Reduced Blocking and Ringing Artifacts", IEEE Transactions on Signal Processing, Vol. 46, Issue 4, April 1998, pp. 1043-1053.	

Examiner  
SignatureDate  
Considered

4/3/06

\*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form (with next communication) to applicant. <sup>1</sup> Applicant's unique citation designation number (optional). <sup>2</sup> See Kinds Codes of USPTO Patent Documents at [www.uspto.gov](http://www.uspto.gov) or MPEP 801.04. <sup>3</sup> Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). <sup>4</sup> For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. <sup>5</sup> Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. <sup>6</sup> Applicant is to place a check mark here if English language translation is attached.

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,113	01/24/2001	Ye Wang	04770-00012	5357

7590 01/26/2004  
Joseph Stecwycz  
BANNER & WITCOFF, LTD.  
28 State Street, 28th Floor  
Boston, MA 02109

EXAMINER
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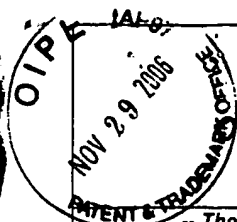
JACKSON, JAKIEDA R

ART UNIT	PAPER NUMBER
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2655

DATE MAILED: 01/26/2004

Please find below and/or attached an Office communication concerning this application or proceeding.



## Office Action Summary

Application No.

09/770,113

Applicant(s)

WANG, YE

Examiner

Jakieda R Jackson

Art Unit

2655

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --  
Period for Reply

### A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

### Status

- 1) ☐ Responsive to communication(s) filed on \_\_\_\_.
- 2a) ☐ This action is FINAL. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

### Disposition of Claims

- 4) ☒ Claim(s) 1-18 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_ is/are allowed.
- 6) ☐ Claim(s) 1-18 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_ are subject to restriction and/or election requirement.

### Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on 24 January 2001 is/are: a) ☐ accepted or b) ☒ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☒ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

### Priority under 35 U.S.C. §§ 119 and 120

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).  
a) ☐ All b) ☐ Some \* c) ☐ None of:  
1. ☐ Certified copies of the priority documents have been received.  
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_.  
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).  
\* See the attached detailed Office action for a list of the certified copies not received.
- 13) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application) since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.  
a) ☐ The translation of the foreign language provisional application has been received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121 since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

### Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892) 4) ☐ Interview Summary (PTO-413) Paper No(s). \_\_\_\_
- 2) ☒ Notice of Draftsperson's Patent Drawing Review (PTO-948) 5) ☐ Notice of Informal Patent Application (PTO-152)
- 3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 3, 5-8. 6) ☐ Other: \_\_\_\_



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NOV 29 2006  
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# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

Use as many sheets as necessary)

Sheet 2 of 2

## Complete if Known

Application Number	09/770,113
Filing Date	Jan. 24, 2001
First Named Inventor	Wang, Ye
Group Art Unit	2438 2655
Examiner Name	TBD
Attorney Docket Number	004770.00012

## OTHER PRIOR ART -- NON PATENT LITERATURE DOCUMENTS

Examiner Initials *	Cite No. <sup>1</sup>	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T <sup>2</sup>
[Signature]	F	BOSSE, Modified Discrete Cosine Transform (MDCT), March 7, 1998, available at <a href="http://ccrma-www.stanford.edu/~bosse/proj/node27.html">http://ccrma-www.stanford.edu/~bosse/proj/node27.html</a>	
	G	FRAUNHOFER, MPEG Audio Layer-3, available at <a href="http://www.iis.fhg.de/amm/techn/layer3/index.html">http://www.iis.fhg.de/amm/techn/layer3/index.html</a>	
	H	WCDMAN - the wideband 'radio pipe' for 3G services, September 17, 1999, available at <a href="http://www.ericsson.com/wireless/productsys/gsm/subpages/umts_and_3g/wcdman.shtml">http://www.ericsson.com/wireless/productsys/gsm/subpages/umts_and_3g/wcdman.shtml</a>	
	I	GSM Frequently Asked Questions, October 23, 2000, available at <a href="http://www.gsmworld.com/technology/faw.html">http://www.gsmworld.com/technology/faw.html</a>	
	J	PERKINS, HODSON, Options for Repair of Streaming Media, Network Working Group RFC 2354, The Internet Society, June 1998.	

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Technology Center 2100

Examiner Signature [Signature] Date Considered 12/11/03

\*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

<sup>1</sup> Unique citation designation number (optional). <sup>2</sup> Applicant is to place a check mark here if English language Translation is attached.

Burden Hour Statement: This form is estimated to take 2.0 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

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**INFORMATION DISCLOSURE  
STATEMENT BY APPLICANT**

(use as many sheets as necessary)

Sheet 2 of 2

**Complete if Known**

Application Number	09/770,113
Filing Date	Jan. 24, 2001
First Named Inventor	Wang, Ye
Group Art Unit	2438 2655
Examiner Name	TBD
Attorney Docket Number	004770.00012

**OTHER PRIOR ART - NON PATENT LITERATURE DOCUMENTS**

Examiner Initials *	Cite No. <sup>1</sup>	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T <sup>2</sup>
	F	BOSSE, Modified Discrete Cosine Transform (MDCT), March 7, 1998, available at <a href="http://ccma-www.stanford.edu/~bosse/proj/node27.html">http://ccma-www.stanford.edu/~bosse/proj/node27.html</a>	
	G	FRAUNHOFER, MPEG Audio Layer-3, available at <a href="http://www.fh-berlin.de/amm/techinfo/layer3/index.html">http://www.fh-berlin.de/amm/techinfo/layer3/index.html</a>	
	H	WCDMAN - the wideband 'radio pipe' for 3G services, September 17, 1999, available at <a href="http://www.ericsson.com/wireless/productsys/gsm/subpages/umts_and_3g/wcdman.shtml">http://www.ericsson.com/wireless/productsys/gsm/subpages/umts_and_3g/wcdman.shtml</a>	
	I	GSM Frequently Asked Questions, October 23, 2000, available at <a href="http://www.gsmworld.com/technology/faw.html">http://www.gsmworld.com/technology/faw.html</a>	
	J	PERKINS, HODSON, Options for Repair of Streaming Media, Network Working Group RFC 2354, The Internet Society, June 1998.	

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<sup>1</sup> Unique citation designation number (optional). <sup>2</sup> Applicant is to place a check mark here if English language Translation is attached.

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US007069208B2

(12) **United States Patent**  
**Wang**

(10) **Patent No.:** **US 7,069,208 B2**

(45) **Date of Patent:** **Jun. 27, 2006**

(54) **SYSTEM AND METHOD FOR  
CONCEALMENT OF DATA LOSS IN  
DIGITAL AUDIO TRANSMISSION**

(75) **Inventor:** Ye Wang, Tampere (FI)

(73) **Assignee:** Nokia, Corp., Espoo (FI)

(\*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 819 days.

(21) **Appl. No.:** 09/770,113

(22) **Filed:** Jan. 24, 2001

(65) **Prior Publication Data**

US 2002/0133764 A1 Sep. 19, 2002

(51) **Int. Cl.**  
**G10L 19/14** (2006.01)

(52) **U.S. Cl.** ..... 704/211; 704/503; 704/228;  
725/36

(58) **Field of Classification Search** ..... 704/211,  
704/503, 228; 725/36  
See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

- \* 5,040,217 A 8/1991 Brandenburg et al.
- \* 5,148,487 A 9/1992 Nagai et al.
- \* 5,256,832 A \* 10/1993 Miyake ..... 84/636
- \* 5,285,498 A 2/1994 Johnston
- \* 5,361,278 A \* 11/1994 Vaupel et al. .... 375/240
- \* 5,394,473 A 2/1995 Davidson
- \* 5,481,614 A 1/1996 Johnston
- \* 5,579,430 A 11/1996 Grill et al.
- \* 5,636,276 A 6/1997 Brugger
- \* 5,841,979 A 11/1998 Schulhof et al.
- \* 5,852,805 A \* 12/1998 Hiratsuka et al. .... 704/500
- \* 5,875,257 A 2/1999 Marrin et al.
- \* 5,928,330 A 7/1999 Goetz et al.
- \* 6,005,658 A 12/1999 Kaluza et al.
- \* 6,064,954 A \* 5/2000 Cohen et al. .... 704/207

- \* 6,115,689 A 9/2000 Malvar
- \* 6,125,348 A 9/2000 Levine
- \* 6,141,637 A 10/2000 Kondo
- \* 6,175,632 B1 1/2001 Marx
- \* 6,199,039 B1 \* 3/2001 Chen et al. .... 704/229
- \* 6,287,258 B1 9/2001 Phillips
- \* 6,305,943 B1 10/2001 Pougatchev et al.
- \* 6,453,282 B1 \* 9/2002 Hilpert et al. .... 704/200.1
- \* 6,477,150 B1 11/2002 Maggenti et al.
- \* 6,597,961 B1 7/2003 Cooke
- \* 6,738,524 B1 5/2004 de Queiroz
- \* 6,787,689 B1 9/2004 Chen
- \* 6,807,526 B1 10/2004 Touimi et al.

**FOREIGN PATENT DOCUMENTS**

- \* DE 197 36 669 10/1998
- \* EP 0 703 712 A2 3/1996
- \* EP 0 718 982 A2 6/1996
- \* EP 1 207 519 5/2002
- \* WO WO 93/26099 6/1993
- \* WO WO 98/13965 4/1998

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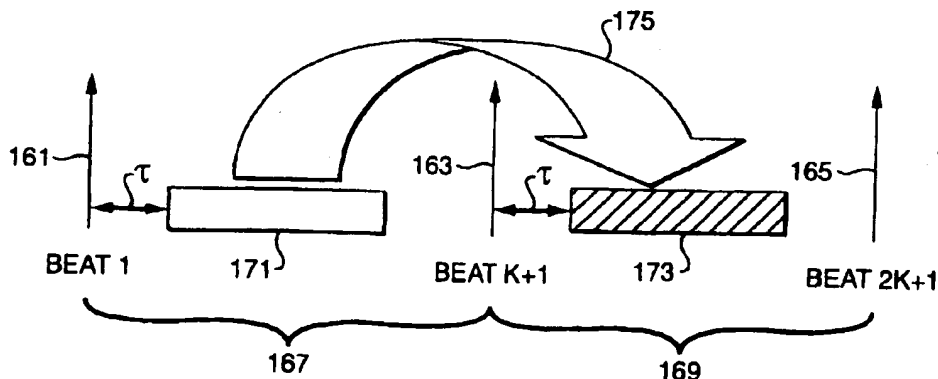
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(57) **ABSTRACT**

A system and method for the concealment of errors resulting from missing or corrupted data in the transmission of audio signals in compressed digital packet formats is disclosed. The system utilizes a circular FIFO buffer to store audio frames from the transmitted audio signal, and a beat detector, to identify the presence of beats in the audio signal. The error concealment method replaces erroneous audio frames with error-free audio frames by a process which takes into account the presence and location of the detected beats.

**42 Claims, 15 Drawing Sheets**



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277. The actual value may vary according to the particular application. In FIG. 8, for example, the threshold 249 has been set at 0.1. Accordingly, a beat has been identified at a peak location 255. This beat would have been missed if the value for the threshold 249 had been greater than 0.1.

When errors occur in audio transmittal applications using the Global System for Mobile Communications (GSM) protocol, the errors normally occur at random. Occasional losses of single or double packets are more likely to occur in Internet applications, where each packet has a duration of about 20 msec, to give a packet-loss error of about 40 msec in duration. Using this model, the capacity requirement of the circular FIFO buffer 50 can be reduced. When the reduced memory capacity is used, fewer audio data frames need to be stored in the circular FIFO buffer 50.

In an alternative embodiment, the memory storage capacity of the circular FIFO buffer 50 can be reduced by storing only selected audio frames rather than every audio frame in the incoming stream. In a first example, shown in FIG. 12, two audio frames 301 and 303 at strong beat 1 are stored in the circular FIFO 50. Additionally, two audio frames 305 and 307 at offbeat 2 are stored, two audio frames 309 and 311 at strong beat 3 are stored, and two audio frames 313 and 315 at offbeat 4 are stored in the circular FIFO 50. Note that none of the audio frames occurring between audio frames 303 and 305, between audio frames 307 and 309, and between audio frames 311 and 313 are stored. Accordingly, when a defective audio frame 323 (frame 0) is identified, the defective frame 323 can be replaced by audio frame 301 since the defective audio frame 323 occurs at a beat 327. In a conventional error concealment method, the defective audio frame 323 could be replaced by either a previous audio frame 321 (frame-1) or by a subsequent audio frame 325 (frame+1).

The group of audio frames denoted by 'n' includes four audio frames of which the audio frame 323 (frame 0), indicates the audio frame currently being sent to the listener via a loudspeaker, for example. The previously-received audio frame is audio frame 321 (frame-1), and the next frame after the audio frame 323 is the audio frame 325 (frame+1). The audio frame 325 is the next available audio frame to be decoded.

In another embodiment, shown in FIG. 13, only two audio frames 331 and 333 at strong beat 1 and two audio frames 335 and 337 at offbeat 2 have been stored, so as to place a smaller demand on the memory storage capacity of the circular FIFO 50. The next-arriving audio frame 345 (frame+1) is interpolated with the previous audio frame 341 to produce replacement data for a corrupted audio frame 343 (frame 0). In the embodiment of FIG. 14, four audio frames 351 (frame 0), 353 (frame+1), 355 (frame+2), and 357 (frame+3) have been lost. Since this loss occurred at a beat location, the audio frames are replaced by previously-stored audio frames 361 and 363 occurring at strong beat 1. The audio frame 351 can be replaced by a previous audio frame 365 (frame-1), and the audio frame 357 can be replaced by the next audio frame 367 (frame+4) in the audio stream.

FIG. 15 presents as a block diagram the structure of a mobile phone 400, also known as a mobile station, according to the invention, in which a receiver section 401 includes a beat detector control block 405 included in an audio decoder 403. A received audio signal is obtained from a memory 407 where the audio signal has been stored digitally. Alternatively, audio data may be obtained from a microphone 409 and sampled via an A/D converter 411. The audio data is encoded in an audio encoder 413 after which the processing of the base frequency signal is performed in

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block 415. The channel coded signal is converted to radio frequency and transmitted from a transmitter 417 through a duplex filter 419 (DPLX) and an antenna 421 (ANT). At the receiver section 401, the audio data is subjected to the decoding functions including beat detection, according to any of the teachings of the alternative embodiments explained above. The recorded audio data is directed through a D/A converter 423 to a loudspeaker 425 for reproduction.

FIG. 16 presents an audio information transfer and audio download and/or streaming system 450 according to the invention, which system comprises mobile phones 451 and 453, a base transceiver station 455 (BTS), a base station controller (BSC) 457, a mobile switching center 459 (MSC), telecommunication networks 461 and 463, and user terminals 465 and 467, interconnected either directly or over a terminal device, such as a computer 469. In addition, there may be provided a server unit 471 which includes a central processing unit, memory, and a database 473, as well as a connection to a telecommunication network, such as the internet, an ISDN network, or any other telecommunication network that is in connection either directly or indirectly to the network into which the terminal having the decoder, including the beat detector of the invention, is capable of being connected either wirelessly or via a wired line connection. In audio data transfer system, according to the invention, the mobile stations and the server are point-to-point connected, and the user of the terminal 451 has a terminal including the beat detector in its decoder of the receiver, as shown in FIG. 15. The user of the terminal 451 selects audio data, such as a short interval of music or a short video with audio music, for downloading to the terminal. In the select request from the user, the terminal address is known to the server 473 and the detailed information of the requested audio data (or multimedia data) in such detail that the requested information can be downloaded. The server 471 then downloads the requested information to the other connection end, or if connectionless protocols are used between the terminal 451 and the server 471, the requested information is transferred by using a connectionless connection in such a way that recipient identification of the terminal is attached to the sent information. When the terminal 451 receives the audio data as requested, it could be streamed and played in the loudspeaker of the receiver terminal in which the error concealment is achieved by applying the beat detection in accordance with one embodiment of the invention.

The above is a description of the realization of the invention and its embodiments utilizing examples. It should be self-evident to a person skilled in the relevant art that the invention is not limited to the details of the above presented examples, and that the invention can also be realized in other embodiments without deviating from the characteristics of the invention. Thus, the possibilities to realize and use the invention are limited only by the claims, and by the equivalent embodiments which are included in the scope of the invention.

What is claimed is:

1. A method for concealing errors detected in an input digital audio bit stream, the audio bit stream configured as a series of frames, said method comprising the steps of:

- detecting a first beat and a subsequent plurality of beats in the audio bit stream;
- defining a first inter-beat interval extending between said first beat and a  $(k+1)^{th}$  subsequent beat;
- storing at least a portion of the audio bit stream occurring within said first inter-beat interval;

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detecting an erroneous audio segment occurring in a second inter-beat interval extending between said  $(k+1)^{th}$  beat and a  $(2k+1)^{th}$  subsequent beat; and replacing at least a first part of said erroneous audio segment with a corresponding part of said stored audio bit stream portion, wherein the corresponding part is selected based on a time relationship between the first part and one of the  $(k+1)^{th}$  and  $(2k+1)^{th}$  beats.

2. A method as in claim 1 wherein 'k' is an integer greater than or equal to 2.

3. A method as in claim 1 wherein said stored audio bit stream portion includes at least one frame positioned on at least one of said beats.

4. A method as in claim 1 wherein said step of detecting a first beat comprises a step of computing the variance of the audio bit stream using decoded IMDCT coefficients.

5. A method as in claim 1 wherein said step of detecting a first beat comprises a step of utilizing a window-switching pattern.

6. A method as in claim 1 wherein said step of detecting a first beat comprises a step of computing the envelope of the audio bit stream using decoded IMDCT coefficients.

7. A method as in claim 1 wherein said step of detecting a first beat comprises steps of computing the variance of the audio bit stream using decoded IMDCT coefficients and utilizing a window-switching pattern.

8. A method as in claim 1 wherein said step of storing at least a portion of the audio bit stream includes a step of storing said portion in a circular first-in first-out (FIFO) buffer.

(10) 9. A method as in claim 1 wherein the audio bit stream includes a music signal.

(12) 10. A method as in claim 1 wherein the erroneous audio segment is the result of at least one of a packet loss from an IP network and a burst error from a wireless channel.

(14) 11. A method as in claim 1 further comprising the step of replacing one beat with another beat from a preceding bar.

(16) 12. A method as in claim 1, wherein the first part has a time displacement  $\tau$  from one of the  $(k+1)^{th}$  and  $(2k+1)^{th}$  beats, and wherein the corresponding part is selected so as to have the same time displacement  $\tau$  from one of the first and  $(k+1)^{th}$  beats.

(20) 13. A method as in claim 1, further comprising:

determining a confidence score, the confidence score being a percentage of correct beat detection within an observation window; and

discontinuing said replacing step when the confidence score is below a threshold value.

(24) 14. A method as in claim 1, further comprising estimating an inter-beat interval according to the formula

$$IBI_i = IBI_{i-1} * (1 - \alpha) + IBI_{new} * \alpha,$$

wherein  $IBI_i$  is a current estimation of the inter-beat interval,  $IBI_{i-1}$  is a previous estimation of the inter-beat interval,  $IBI_{new}$  is a most recently-detected inter-beat interval, and  $\alpha$  is a weighting parameter.

(28) 15. A method as in claim 1, wherein said storing comprises minimizing storage requirements by only storing frames adjacent to a strong beat or to an offbeat.

(32) 16. A method as in claim 1, further comprising replacing a corrupted audio frame by interpolating preceding and succeeding audio frames.

(36) 17. A method as in claim 1, further comprising replacing a second part of the erroneous audio segment preceding the first part of the erroneous audio segment with a frame preceding the second part.

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(40) 18. A method as in claim 1, further comprising replacing a second part of the erroneous audio segment following the first part of the erroneous audio segment with a frame following the second part.

5 (44) 19. A method as in claim 1, further comprising:

replacing a second part of the erroneous audio segment preceding the first part of the erroneous audio segment with a frame preceding the second part; and

10 replacing a third part of the erroneous audio segment following the first part of the erroneous audio segment with a frame following the third part.

(48) 20. A method as in claim 5, wherein said detecting a first beat and a subsequent plurality of beats further comprises:

15 detecting strong beats and off-beats, and

determining an interval between strong beats based on a statistical probability of inter-beat intervals.

(52) 21. A method as in claim 20, wherein said detecting a first beat and a subsequent plurality of beats further comprises:

20 determining the interval between strong beats based on a most probable inter-beat interval of approximately 600 ms.

(56) 22. A wireless terminal comprising:

25 a receiver section having a beat detector and an audio decoder, wherein the receiver section is configured to perform steps comprising

detecting a first beat and a subsequent plurality of beats in an audio bit stream,

30 defining a first inter-beat interval extending between said first beat and a  $(k+1)^{th}$  subsequent beat,

storing at least a portion of the audio bit stream occurring within said first inter-beat interval,

35 detecting an erroneous audio segment occurring in a second inter-beat interval extending between said  $(k+1)^{th}$  beat and a  $(2k+1)^{th}$  subsequent beat, and

replacing at least a first part of said erroneous audio segment with a corresponding part of said stored audio bit stream portion, wherein the corresponding part is selected based on a time relationship between the first part and one of the  $(k+1)^{th}$  and  $(2k+1)^{th}$  beats.

(60) 23. The wireless terminal of claim 22, wherein 'k' is an integer greater than or equal to 2.

(64) 24. The wireless terminal of claim 22, wherein said stored audio bit stream portion includes at least one frame positioned on at least one of said beats.

(68) 25. The wireless terminal of claim 22, wherein said step of detecting a first beat comprises a step of computing the variance of the audio bit stream using decoded IMDCT coefficients.

(72) 26. The wireless terminal of claim 22, wherein said step of detecting a first beat comprises the step of utilizing a window-switching pattern.

(76) 27. The wireless terminal of claim 22, wherein said step of detecting a first beat comprises a step of computing the envelope of the audio bit stream using decoded IMDCT coefficients.

60 (80) 28. The wireless terminal of claim 22, wherein said step of detecting a first beat comprises steps of computing the variance of the audio bit stream using decoded IMDCT coefficients and utilizing a window-switching pattern.

(84) 29. The wireless terminal of claim 22, wherein said step of storing at least a portion of the audio bit stream includes a step of storing said portion in a circular first-in first-out (FIFO) buffer.

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- (37)30. The wireless terminal of claim 22, wherein the audio bit stream includes a music signal.
- (38)31. The wireless terminal of claim 22, wherein the erroneous audio segment is the result of at least one of a frame loss from an IP network and a burst error from a wireless channel.
- (39)32. The wireless terminal of claim 22, wherein the first part has a time displacement  $\tau$  from one of the  $(k+1)^{th}$  and  $(2k+1)^{th}$  beats, and wherein the corresponding part is selected so as to have the same time displacement  $\tau$  from one of the first and  $(k+1)^{th}$  beats.
- (40)33. The wireless terminal of claim 22, wherein the receiver section is configured to perform steps comprising:  
determining a confidence score, the confidence score being a percentage of correct beat detection within an observation window, and  
discontinuing said replacing step when the confidence score is below a threshold value.
- (41)34. The wireless terminal of claim 22, wherein the receiver section is configured to perform steps comprising:  
estimating an inter-beat interval according to the formula

$$IBI_i = IBI_{i-1} * (1 - \alpha) + IBI_{new} * \alpha,$$

wherein  $IBI_i$  is a current estimation of the inter-beat interval,  $IBI_{i-1}$  is a previous estimation of the inter-beat interval,  $IBI_{new}$  is a most recently-detected inter-beat interval, and  $\alpha$  is a weighting parameter.

- (42)35. The wireless terminal of claim 22, wherein said storing comprises minimizing storage requirements by only storing frames adjacent to a strong beat or to an offbeat.
- (43)36. The wireless terminal of claim 22, wherein the receiver section is configured to perform steps comprising:  
replacing a corrupted audio frame by interpolating preceding and succeeding audio frames.

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- (44)37. The wireless terminal of claim 22, wherein the receiver section is configured to perform steps comprising:  
replacing a second part of the erroneous audio segment preceding the first part of the erroneous audio segment with a frame preceding the second part.
- (45)38. The wireless terminal of claim 22, wherein the receiver section is configured to perform steps comprising:  
replacing a second part of the erroneous audio segment following the first part of the erroneous audio segment with a frame following the second part.
- (46)39. The wireless terminal of claim 22, wherein the receiver section is configured to perform steps comprising:  
replacing a second part of the erroneous audio segment preceding the first part of the erroneous audio segment with a frame preceding the second part, and  
replacing a third part of the erroneous audio segment following the first part of the erroneous audio segment with a frame following the third part.
- (47)40. The wireless terminal of claim 26, wherein said detecting a first beat and a subsequent plurality of beats further comprises:  
detecting strong beats and off-beats, and  
determining an interval between strong beats based on a statistical probability of inter-beat intervals.
- (48)41. The wireless terminal of claim 40, wherein said detecting a first beat and a subsequent plurality of beats further comprises:  
determining the interval between strong beats based on a most probable inter-beat interval of approximately 600 ms.
- (49)42. The wireless terminal of claim 22, wherein the receiver section is configured to perform the step of replacing one beat with another beat from a preceding bar.

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